The Saudi Journal for Dental Research (2016) 7, 101–105

King Saud University

The Saudi Journal for Dental Research

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ORIGINAL ARTICLE

Linear measurements of finish line length associated with various preparation designs using CAD/CAM technology

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Received 24 March 2015; revised 9 April 2015; accepted 11 April 2015
Available online 27 April 2015

KEYWORDS

Laboratory research;
Tooth preparation design;
Finish line;
CAD–CAM

Abstract *Purpose:* The aim of this study was to measure the length of finish lines associated with various commonly used preparation designs using high technology CAD/CAM.
Materials and methods: A total of 80 extracted human permanent teeth (including 4 distinct morphologies) were divided into 8 groups according to the type of preparation design (all-ceramic crown, ceramic onlay, or ceramic veneer) and tooth type (upper first molar, lower first premolar, upper central incisor and lower central incisor). The length of the finish line for each specimen was measured after performing tooth preparation using Dental Wings 7Series 3D Scanners. The measured lengths associated with the various preparation designs were analyzed.
Results: The length of the finish line was significantly different between complete- and partial -coverage tooth preparations, in which the partial coverage had a longer finish line than the complete coverage.
Conclusion: The complete-coverage preparations evaluated in this study exhibited significantly shorter finish lines compared to the partial-coverage preparations.
Clinical significant: The risk of recurrent caries has been directly related to the marginal integrity of any restoration. However, the relationship between the length of the finish line and recurrent decay may also be significant. Therefore, obtaining baseline information regarding the differences in finish line length of various preparation designs is important.

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

1. Introduction

In daily practice, the dental clinician is faced with the issue of replacing missing tooth structure or missing teeth using single crowns or fixed partial dentures (FPD). In 2009, Walton reported the number of new prostheses between 1991 and 2007 and showed that the incidence of tooth-supported single crowns (TSCs) and tooth-supported fixed dental prostheses

http://dx.doi.org/10.1016/j.sjdr.2015.04.001

(TFDPs) provided in his practice was 60% and 34%, respectively.[1]

Recurrent caries around the margins of fixed dental prostheses is a common clinical complication. In a 16-year clinical study of porcelain veneers, recurrent marginal caries was observed in 6% of the abutments. Similarly, 3% of recurrent caries was associated with abutments that received all-ceramic crowns in a 5-year clinical study.[2,3]

Various preparation designs have distinct finish lines. Although, the length of the finish line could have an effect on the marginal recurrent caries which subsequently affect the success of the prosthesis, however, the length of the various finish lines designs have never been quantitatively estimated by the researchers.

Several methods can be used to measure the linear distance of the finish line such as cord wrapping around the finish line of the preparation, then cutting it precisely and measuring it against a regular ruler. CAD/CAM technology (computer aided design/computer aided manufacturing) can also be used to measure the length of the finish line, after tooth scanning and during designing phase of a restoration, the finish line of the preparation could be traced and measured accurately. This technique provides a high level of optical impression accuracy which is important for fabrication of a precise restoration.[4]

To the knowledge of the investigators, no study has measured the length of the finish line associated with various preparation designs. Accordingly none had used the high technology CAD/CAM for linear measurement. Therefore, the aim of this study was to measure the length of the finish line associated with several commonly used preparation designs using CAD/CAM technology. The null hypothesis was that there is no difference in the length of the finish line between partial- and complete-coverage preparations.

2. Materials and methods

A total of 80 extracted, human, permanent teeth were considered in this study; these teeth satisfied the following inclusion criteria: no visible defects, no restorations or caries, and no enamel malformations.

Calculus deposits and soft tissues were removed from the selected teeth using an ultrasonic scaler (Sirosonic L, Sirona, Bensheim, Germany). The teeth were stored in saline (0.9% sodium chloride) solution at room temperature from the time of extraction until the investigation was conducted to prevent desiccation.

Each specimen was aligned vertically in a polymer tube and embedded in a dental plaster (SHERAALABASTER, Shera Werkstoff Technologie Gmbh Co., Lemforde, Germany) 2 mm apical to the cementoenamel junction (CEJ). A dental surveyor (The J. M. NEY Company, Yucaipa, CA, USA) was used to position the long axis of each tooth parallel to the tube.

2.1. Tooth distribution

The specimens contained 4 distinct tooth morphologies (maxillary first molar, mandibular first premolar, upper central incisor, and lower central incisor) and were distributed into 8 subgroups according to tooth morphology and preparation design (ceramic crown, ceramic onlay, or ceramic veneer). The teeth were randomly assigned to the preparation groups (8 groups). Randomization was performed by a blinded participant who randomly distributed 80 opaque containers (20 containers for each tooth morphology) into 2 subgroups (crown or veneer, crown or onlay) for each tooth morphology.

2.2. Tooth preparation

The preparations were controlled using a transparent template (0.020″, Buffalo Dental Manufacturing Co., Ontario, Canada) and a scaled periodontal probe (Williams SE Perio PROBE, Hu-Friedy, Chicago, USA). The suggested guidelines for standardized preparation design were followed.[5–8]

The preparations were made using diamond burs (Drendel + Zeweiling, Germany) at a high speed. The preparations were then refined. Any sharp internal line angles were removed, the pulpal and gingival floors were smoothed, and the walls were finished with a fine diamond bur at 40,000 rpm. All preparations were performed with copious water irrigation.

2.3. Finish line length measurement

All the teeth were stabilized on a special scanning plate and underwent scanning using Dental Wings 7Series 3D Scanners (Dental – Wings Inc., Montreal, QC, Canada) (Figs. 1 and 2). Powder spraying (spray marker, Amann Girrbach AG, Koblach, Austria) was applied to all the teeth before scanning to improve visual characteristics.

After scanning and at the designing phase of the prosthesis the finish lines of all the preparations were traced and measured in millimeters using 4.0.3.29939, Software Ortho Client DW (Dental – Wings Inc., Montreal, QC, Canada) (Fig. 3).

2.4. Statistical analysis

Descriptive statistics were used to describe the finish line length. The Student *t*-test was used to compare the mean values of finish line length between complete and partial coverage preparations, and a *P*-value $< .05$ was considered statistically significant.

3. Results

Table 1 presents the mean values and standard deviations of the finish line length associated with the various preparation designs.

The ceramic onlay for the upper first molar had the longest finish line (43.23 ± 2.22 mm), while the shortest finish line was associated with all-ceramic crown for the lower central incisor (16.48 ± 1.78 mm).

The length of the finish line is significantly different between the complete- and partial-coverage preparations, in which the mean length was significantly higher ($P < 0.001$) for partial coverage preparations (ceramic onlay and ceramic veneer) compared with complete coverage preparations (all-ceramic crown).

Regarding teeth morphology, lower central incisors have the shortest finish lines for both complete- and partial-coverage preparations, followed by the upper central incisor and lower

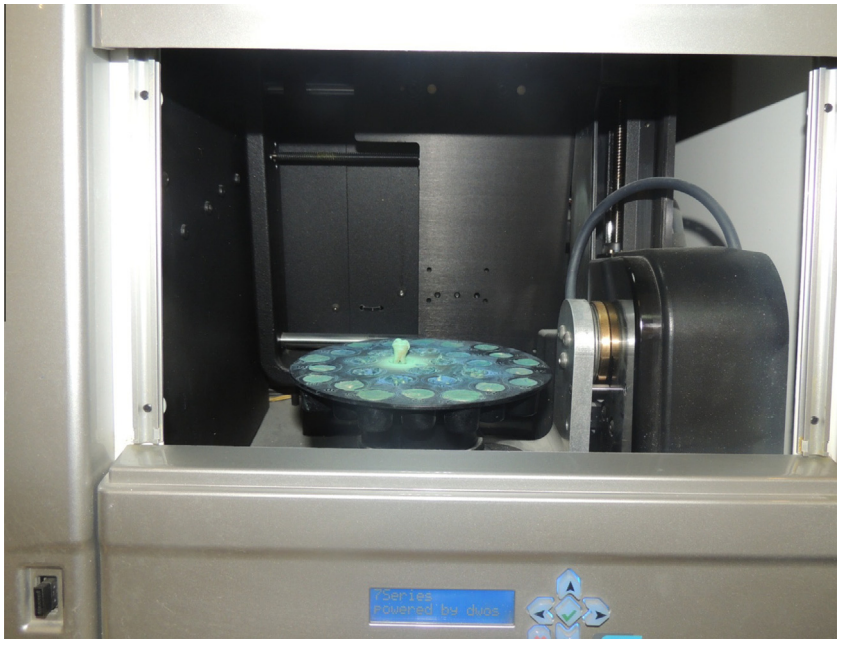

Figure 1 Dental Wings 7Series 3D Scanners (scanning plate).

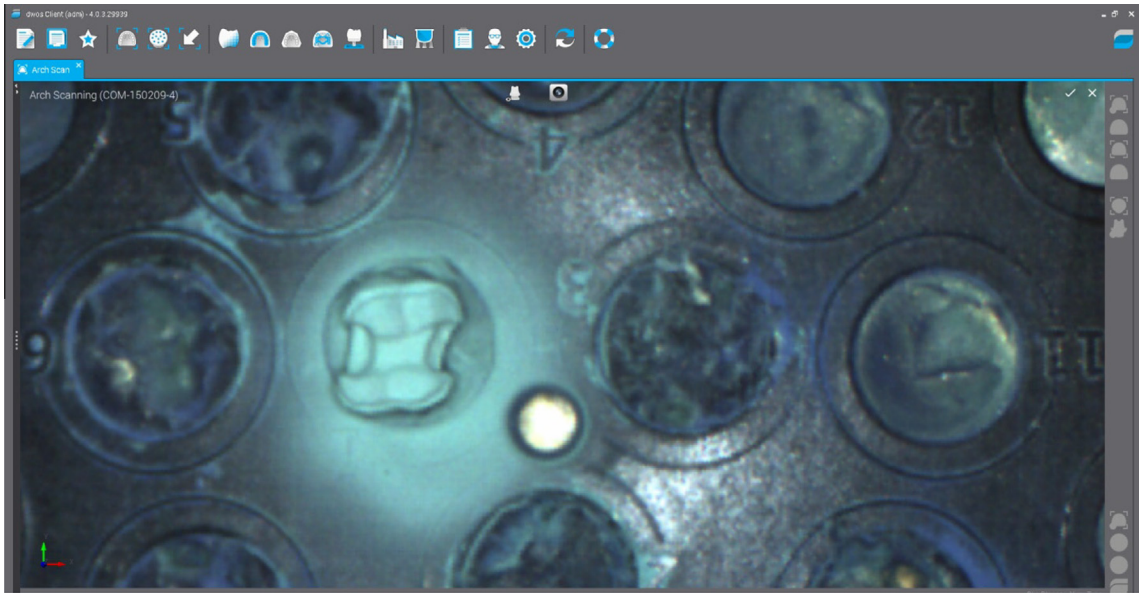

Figure 2 Specimen scanning.

first premolar, whereas the longest finish lines were associated with preparations done on the upper first molar.

4. Discussion

Preservation of tooth structure is a fundamental principle during tooth preparation. In the literature multiple studies quantified the removed tooth structure associated with different preparation designs and compared between complete and partial coverage designs,[5,6,8–10] however none had measured the length of the finish line of these designs which may associate with more marginal recurrent caries.

The proposed null hypothesis of this study was rejected because a difference was observed in the mean length of the finish line between partial- and complete-coverage preparations.

The partial coverage preparation design like ceramic onlay and ceramic veneer preserves more tooth structure than the complete coverage preparation (all-ceramic crown),[5,6,8–10] on the other hand it is associated with a longer finish line which may increase the risk of marginal recurrent caries.

Marginal caries is a factor responsible for the loss of serviceability of fixed prosthesis. Goodacre et al. evaluated 1650 teeth in 13 studies that received all ceramic crowns. Thirteen teeth developed caries lesions with a mean incidence of 0.8%.[11] In 5 years' clinical performance of porcelain veneer,

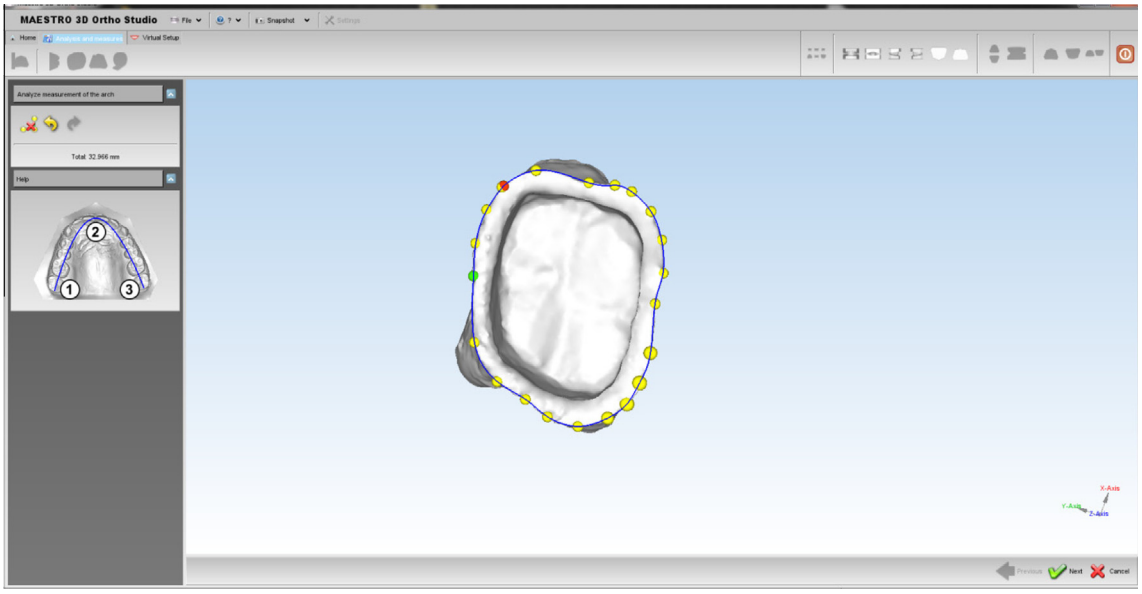

Figure 3 Measuring the finish line length of the preparation (3D model of upper first molar).

Table 1 Mean values and standard deviations of finish line lengths associated with various preparation designs.

Preparation designs	*N*	Mean	Std. deviation	Minimum	Maximum	Mean difference	95% confidence interval of the difference of the mean		*P*-value
							Lower bound	Upper bound	
LCC	10	16.48	1.78	14.43	20.24	5.12	3.38	6.86	< .000
LCV	10	21.60	1.92	17.54	23.7				
UMC	10	34.55	1.96	31.25	37.2	8.68	6.1	10.65	< .000
UMO	10	43.23	2.22	38.72	46.29				
LPC	10	20.40	1.65	18.32	23.42	10.01	8.08	11.93	< .000
LPO	10	30.41	2.38	25.97	33.16				
UCC	10	23.97	1.65	21.83	26.26	6.35	4.25	8.45	< .000
UCV	10	30.32	2.70	26	34.55				

LCC: lower central incisor, all-ceramic crown.
LCV: lower central incisor, ceramic veneer.
UMC: upper first molar, all-ceramic crown.
UMO: upper first molar, ceramic onlay.
LPC: lower first premolar, all-ceramic crown.
LPO: lower first premolar, ceramic onlay.
UCC: upper central incisor, all-ceramic crown.
UCV: upper central incisor, ceramic veneer.

Puemans et al. reported that 2.3% of 87 maxillary anterior teeth that received porcelain veneer developed marginal recurrent caries.[12] In private sector, Otto & De Nisco evaluated 187 Cerec CAD/CAM Inlays and onlays over a period of 10 years. 3% of the restorations were failed due to recurrent caries.[13]

In the present study, there was a highly significant difference between the finish line lengths between complete (all-ceramic crown) and partial (porcelain veneer and onlay) tooth coverage preparations among all the specimens which may contribute to the increased prevalence of marginal recurrent caries around porcelain veneers compared to all-ceramic crowns.[2,3]

Tooth type may affect the length of preparation of finish line. Teeth with a larger circumference have a longer finish line. For example, lower central incisors with the lowest tooth circumference had the shortest finish line, and the opposite applied for the upper first molar.

In the present study the lengths of the finish lines of tooth preparations were measured using CAD/CAM technology. The finish lines were traced and measured after teeth scanning, which is considered a more accurate method compared to other conventional methods like cord wrapping around the finish line which may be subjected to cord overlapping or stretching during the measurements.

5. Conclusions

Within the limitations of the present study, the following conclusions can be drawn:

1. The length of the finish line of prepared teeth varies according to the preparation design.
2. Within this study, the complete-coverage preparations exhibited shorter finish lines compared to the partial-coverage preparations.
3. Using CAD/CAM technology provides a method for linear measurement of tooth structure.

6. Clinical significance

The risk of recurrent caries has been directly related to the marginal integrity of any restoration. However, the relationship between the length of the finish line and recurrent decay may also be significant. Therefore, obtaining baseline information regarding the differences in finish line length of various preparation designs is important.

Conflict of interest

None declared.

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